

ATTACHMENT C
Amendments to the Specification
Substitute Specification - Clean Copy

Provided hereafter is a clean copy of the amended specification shown in Attachment B.

METHOD IN AN ELECTRIC NET DATA TRANSMISSION SYSTEM
FOR KEEPING THE SIGNAL LEVEL CONSTANT IN A COUPLING
FURNISHED WITH CONNECTING CABLE

5 The common problem with data transmission in a low voltage net, for example 12
VAC/DC, 24 VAC/DC, 48VAC/DC, 115 VAC, 230 VAC and 400VAC, is the weakening of the
transmission signal due to the connecting cable and due to the load impedance, for instance only
a fraction of signals sent by the transmitter gets between the phase rail and the zero rail. The
problem is most severe when the connecting cable is long and when the load impedance at used
10 signal frequencies is very low. Among other things, this problem can prevent commercial
profiting of net data transmission systems.

 The invention removes the problem by eliminating the impact of the weakening on
coupling capacitor C_C and of the connecting cable with the small values of load impedance.
Thus the standard-allowed maximum signal SFS-EN-50065-1:122 dBuV is produced between
15 the phase rail and the zero rail and in this respect data transmission in a low voltage net is made
reliable even with low net impedance Z_{LOAD} .

 Even in the most advanced solutions of the present technique, where the output signal of
the apparatus is constant, in other words independent of the net impedance, the coupling
capacitor C_C and connecting cable cause weakening of the transmission signal. The situation is
20 especially bad when the net impedance is very low.

 Figure 1 shows the weakening of the transmission signal by a 3 meter connecting cable.
Thereby the weakening is about 7 dB; but if the length of the connecting cable is for instance 10
m, the weakening is about 14 dB (1/5 voltage) when the load impedance Z_{LOAD} is 1 ohm.

 The block diagram of the whole invention is presented in figure 2. The voltage source 10
25 is the source of supply voltage furnished with constant or adjustable output voltage U_S . U_S is the
supply voltage of signal amplifier 20.

 Input signal U_{IN} (e.g., under 95 kHz, 95-125 kHz, 125-140 kHz or 140-148,5 kHz) can be
a sinus or a square signal to its amplitude, e.g. 5 V_{pp}. The input signal is taken by adjustable
amplification or, after signal amplifier 20, furnished with level regulation U_{OUT} to low pass or
30 band pass signal filter 40, where harmonic distortion (crack) signals are filtered out from the

basic frequency signal. Filtered signal \underline{U}_{FL} is then taken to coupling unit 50 and further to the low voltage net, e.g., with a 3 meter connecting cable.

The network impedance between the phase rail and zero rail, the rail impedance, is described by signal frequencies with load impedance \underline{Z}_{LOAD} . The series impedance of the connecting cable is described with impedance \underline{Z}_W . The connecting cable length is L_W .

Dotted broken line A illustrates the traditional idea of the transmitting apparatus, which has an output connector O reference number 51: L-N. Dotted broken line B illustrates an expanded idea of the transmitting apparatus according to this invention. Then the connecting cable is a fixed part of the apparatus and the output terminals of the apparatus, expanded as per this idea, is the connecting cable ends l-n to be connected to the phase and the zero rail. The connecting cable length must be of the prior art as well as its electric and other properties.

The basic idea of this invention is that a connecting cable of certain length and type L_W , \underline{Z}_W is a fixed part of the transmission apparatus and between cable ends l – n, coupled to the network phase rail and zero rail, the rail voltage U_{LOAD} is kept constant by means of feedback coupling. The output coupling L – N of the transmitting apparatus is at the same time a phase and zero rail connection. In this way the transmission signal $\underline{U}_{LOAD}/\underline{Z}_{LOAD}$ amplitude U_{LOAD} , which must be put in between phase and zero rail, is constant.

The internal generator impedance of the signal generator, formed by the transmitter and connecting cable, can in this way be formed almost to a rate of 0 ohm.

The invention is not in contradiction for instance with standard SFS-EN 50065-1, since the load voltage U_{LOAD} between the phase rail and zero rail or in the wall outlet does not under any circumstances exceed the allowed rate 122 dBuV. The same result could be reached also without the invention if the length of connecting cable would be, for instance, only 10-20 cm. Generally, in practice it would, however, be impossible to use such a short length.

OPERATION ALTERNATIVE 1. BLOCKS 60 AND 70

a) Virtual Impedance Method

Steered before actual data transmission by micro processor μP included in process unit 70, the signal amplifier 20 transmits a reference level signal of short duration, e.g., 40 ms, in such a way that the signal amplifier always receives its constant control voltage U_{RC} ($RC =$

REFERENCE CONTROL) from the process unit 70. The level of U_{RC} is such kind that from a load impedance $Z_{LOAD} = 50 \text{ ohm}$, a transmission signal U_{LOAD} in size of e.g. 3,56 V_{pp} would be reached. U_{LC} is out of function.

During transmission, the load impedance (rail impedance) Z_{LOAD} is what it happens to be at that moment. Measuring and handling unit 60 measures the feedback signal U_a from block 20, U_B from block 40 or U_C from block 50 and U_D from block 50. The feedback signal voltages U_a , U_b or U_c are lower the lower that Z_{LOAD} is. The primary current I_C in coupling unit 50 of signal transformer T_C is measured by measuring the signal voltage U_d over series resistor $R = 0,5 \text{ ohm}$. I_C is thus higher the lower that the Z_{LOAD} is.

Alternatively, instead of the above I_C of the signal current, it is also possible to measure the secondary current I_{LOAD} of the signal transformer T_C , which current runs through coupling capacitor C_C to the connecting cable and further to load impedance Z_{LOAD} . The signal voltage U_D to be measured is proportional to signal current I_C or I_{LOAD} . If the I_{LOAD} is measured from the secondary side before or after the coupling capacitor C_C , still a separate coupling unit is needed for coupling of signals U_d and U_c to measuring and handling unit 60.

Alternatively signal voltage U_d can instead of coupling unit 50 be measured from signal amplifier 20 or signal filter 40. Signal voltage U_d gives information of signal current I_{LOAD} in the transmission situation.

The phase angle \varnothing between U_a , U_b , U_c and I_c depends on the phase angle of Z_{LOAD} , in other words to what extent the Z_{LOAD} is resistive, capacitive or inductive. Measuring and handling unit 60 includes a phase difference detector and signal handling circuits and a lot of screening. On the basis of the above data in measuring and handling unit 60, for instance, the following variables are calculated:

$$Z = U_a/I_c, U_b/I_c \text{ or } U_c/I_c \text{ ohm}$$

$$Z/\varnothing = Z$$

$$\varnothing = (U_a, I_c \text{ or } U_b, I_c \text{ or } U_c, I_c)$$

Impedance \underline{Z} is a kind of a virtual impedance, which gives knowledge of the load impedance \underline{Z}_{LOAD} .

In measuring and handling unit 60, direct voltages U_Z and U_\emptyset proportional to measured virtual impedance modulus value Z and phase angle \emptyset are formed and taken to process unit 70 of the microprocessor that by means of U_{LC} memory map transforms them to control voltage U_{LC} to control the amplification of signal amplifier 20 so that load signal voltage U_{LOAD} is constant and the maximum allowable, e.g., 3,56 V_{PP} or 122 dBuV. U_{LC} remains in the holding circuit of process unit 70 till after about 1-4 seconds, at which time it gets removed by a new U_{CL} value determined by the next new reference measuring (LC = LEVEL CONTROL).

All in all, always, for instance for 2 ms – 20 s, e.g., 40 ms, the apparatus sends a transmission signal according to certain reference level, for instance at intervals of 0,5 s - 30 s, e.g. 1 - 4 s. During the mentioned 40 ms, a virtual impedance $\underline{Z} = Z/\emptyset$ somehow proportional to the modulus value and phase angle of load impedance \underline{Z}_{LOAD} is determined, the variables U_Z and U_\emptyset determined by which there is picked from the U_{LC} memory map, Fig. 6, an U_{LC} control voltage to control the amplification of signal amplifier 20 so that the load signal voltage U_{LOAD} is constant, e.g., 3.56 V_{PP} with the load impedance in question.

b) Amplitude Method

Alternatively, for the above presented virtual impedance method (Z/\emptyset), the control voltage U_{LC} of signal amplifier 20 can be formed simply by means of transmission signals \underline{U}_a , \underline{U}_b or \underline{U}_c , and by means of \underline{U}_d amplitude monitoring.

The transmitting apparatus, reckoned from signal amplifier 20 and advancing through the low pass and/or band pass signal filter 40 and the coupling unit 50 to the connecting cable and finally further to the load impedance \underline{Z}_{LOAD} , includes capacitors, resistors, chokes, a transformer and other inductances and capacitors. Accordingly, by means of different load impedance \underline{Z}_{LOAD} values, it is possible to measure from different locations in the apparatus transmission signals of different value (U_a, U_b, U_c, U_d) as to their amplitude. For instance, on basis of amplitude combinations of two signals, as U_b and U_d , the value and nature of load impedance \underline{Z}_{LOAD} can be concluded. It is the question of an amplitude method as an alternative to the virtual impedance method.

Figure 2: Block diagram of the whole invention and figure 6: U_{LC} memory map = U_{LC} (Z, \emptyset).

With control voltage U_{LC} it is possible in addition to block 20 or alternatively to control
5 block 40, 50 and/or block 10. The same also concerns control voltage U_{RC} .

OPERATION ALTERNATIVE 2: BLOCKS (80 AND 90)

Feedback coupling is taken from the phase rail and zero rail. Rail signal voltage is load
signal voltage $\underline{U}_{LOAD} / \underline{Z}_{LOAD} (I_{LOAD} - n_{LOAD})$ or from the wall outlet through coupling
10 unit/feedback 80 to the ALC/ALG/ACC unit 90, where control signal U_{ALC} or U_{AGC} or U_{ACC} is
formed to control the output signal level U_{OUT} of signal amplifier 20 so that load signal voltage
 U_{LOAD} , i.e., rail signal voltage U_{I-n} is constant, in other words independent of the load
impedance \underline{Z}_{LOAD} .

ALC = Automatic Level Control
15 AGC = Automatic Gain Control
ACC = Automatic Cutting Control

Control voltage U_{ALC} , U_{AGC} and/or U_{ACC} can in addition to signal amplifier 20 alternatively
control block 40, 50 and/or block 10. The same is in question also with control voltage U_{RC} .

The coupling unit 50 and the coupling unit/feedback 80 include, in case of galvanic
20 separation, a coupling transformer T_C and T_{CC} and a coupling capacitor C_C and C_{CC} and possibly
also other components. Alternatively there is a so called direct coupling no galvanic separation
from the network, and the coupling units 50 and 80 can in their simplicity include only a
coupling capacitor C_C and C_{CC} .

25 THE FIRST APPLICATION OF THE INVENTION. FIGURE 3

Figure 3 shows first application of the invention. The operating principle is already
described above. In connection with U_{LC} memory map, figure 6, it can be stated that it presents
the control voltage values U_{LC} of the signal amplifier 20 corresponding to 304 different load

impedance \underline{Z}_{LOAD} values, by means of which it is then possible to bring about to the load impedance in question a constant load signal voltage U_{LOAD} 3,56 V_{PP} or 122 dBuV.

In addition to the \underline{Z}_{LOAD} of impedances, it presents the $\underline{Z} = Z \angle \emptyset$ values Z and \emptyset of the measured virtual impedance, as addresses of the storage location, and the U_{LC} value as content of said storage location. The virtual impedance \underline{Z} is, in addition to coupling unit 50, also affected by blocks 20 and 40 preceding it and by the connecting cable. Accordingly, the virtual impedance does not give any good linear picture of load impedance \underline{Z}_{LOAD} , especially in so far as the phase angle \emptyset is concerned. This is due to the fact that from signal amplifier 20 to load impedance \underline{Z}_{LOAD} there are chokes, a transformer, capacitors and a connecting cable, by the interaction of which there are phase distortions as well as different resonance effects. One brilliant idea of the invention is that its above mentioned circumstances are of no importance at all, since it is enough that the virtual impedance in some way depends only on the \underline{Z}_{LOAD} and the connecting cable, and only in some way differing virtual impedance values Z and \emptyset are produced and by this means U_{LC} memory map addresses Z and \emptyset . Then into an appropriate storage location such a control voltage value U_{LC} of the signal amplifier is stored, so that by means of it a proper output signal voltage U_{OUT} of the signal amplifier and a constant load signal voltage, rail signal voltage U_{LOAD} to the appropriate load impedance \underline{Z}_{LOAD} is produced.

The invention functions by dotlike frequencies or by a certain frequency band. An U_{LC} memory map is always needed for frequencies or frequency bands far enough from one another and for different connecting cables. If the virtual impedance is not exactly the same as some storage location address, the closest or a more proper address is chosen.

In the U_{LC} memory map there can be more or even less than 304 storage locations. In practice, a whole swarm of memory maps may be needed. If a sufficient amount of connecting cables of different length and type are used and with frequencies or frequency bands far enough from one another for each case, a unique U_{LC} memory map is needed. Instead of the 3 m length, the connecting cable can be even longer, but then it may be necessary to increase the supply voltage U_s of signal amplifier 20.

The value tolerances of the transmitter components must be small enough precision components or then by each entire transmitter unit an U_{LC} memory map is programmed in a special programming location individually by serial production. This applies to this and the next practical application.

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THE SECOND APPLICATION OF THE INVENTION. FIGURE 4

Instead of the virtual impedance method, the amplitude method can be used in order to generate a control voltage U_{CL} . In the amplitude method, it is possible to determine, on basis of two, for instance U_b and U_d signal voltage amplitudes, from the U_{LC} memory map $U_{LC} = U_{LC}(U_b \text{ and } U_d)$, a control voltage U_{LC} corresponding to load impedance Z_{LOAD} which regulates the output signal amplitude U_{OUT} in signal amplifier 20 so that load signal voltage U_{LOAD} is constant, in other words e.g., 3,5 V_{pp} or 122 dBu V. Quite clear differences have been measured for U_b and U_d , when $Z_{LOAD} = 1 - 50 \text{ ohm}$ and $\varnothing_{LOAD} = 0 - \pm 90^\circ$: $U_{bmax} - U_{bmin} = 6 \text{ V}_{pp}$ and $U_{dmax} - U_{dmin} = 310 \text{ mV}_{pp}/0,5 \text{ ohm}$. The U_b and U_d amplitude can be measured by an A/D transformer, 10 and 8 bits, during transmitting of the reference signal, i.e., output signal voltage U_{OUT} in signal amplifier 20 is constant, for instance 40 ms / 1 - 4 seconds.

The bit figure 10 + 8 received from A/D transformer, corresponding to U_b and U_d , can function directly as an address of the memory map. From the storage location indicated by it, a control voltage U_{LC} , proper for the situation, is reached for signal amplifier 20 by means of the sample and hold circuit in process unit 70. From U_{LC} memory map, the closest or more proper address is chosen if the measured address is not exactly the same. Instead of the A/D transformer, comparator circuits can be used to measure the U_b and U_d levels of transmitted signals by steps.

The U_{LC} memory map presented in figure 6 is suited also for this application of the invention and if the address co-ordinates Z and \varnothing of the storage locations are correspondingly transformed into U_b and U_d , $U_{LC} = U_{LC}(U_b, U_d)$.

The third application of the invention. Figure 5.

Figure 7 shows load signal voltage U_{LOAD} (1) with feedback coupling with blocks 80 and 90 and (2) and without feedback coupling U_{LOAD} as a function of load impedance i.e., rail impedance Z_{LOAD} during transmitting. The output signal of the real apparatus is $U_W + U_{LOAD}$ in net connector 51, L – N with feedback coupling.

Previously known is that the longer the connecting cable L_W , Z_W of the transmitter of a data transmission system in a low voltage net, and the lower the impedance by signal frequencies in the other end of connecting cable as load impedance, rail impedance or net impedance Z_{LOAD} , the lower the load signal voltage U_{LOAD} over Z_{LOAD} during transmitting.

However, previously no effective means were known on how to eliminate the strong weakening of signal caused by the above mentioned circumstances. The problem does not vanish in that the transmitter maintains to keep the signal level constant in its output connector.

OPERATION ALTERNATIVE 1: FIGS 3 AND 4

In the transmitting situation when output signal voltage U_{OUT} in signal amplifier 20 is constant, the reference signal is sent repeatedly but of short duration and during that time one or more transmission signals U_a, b, c, \dots, U_n are measured from different locations of the apparatus i.e., apparatus + connecting cable. Then signal amplitudes, phase shifts (keying), proportions, multiplies, sums and other features are handled and calculated and the control signal U_{LC} from processor unit 70 controls blocks 20, 40, 10 and 50 so that load signal voltage U_{LOAD} is constant, in other words independent of load impedance Z_{LOAD} till the transmitting of the next reference signal that load signal voltage U_{LOAD} is constant, in other words independent of load impedance Z_{LOAD} till the transmitting of the next reference signal. Signals U_a-U_n , U_Z , U_\emptyset , U_{RC} , U_{LC} , U_{ALC} , U_{ACC} and U_{AGC} can instead of the voltage signal be current signals, frequency signals, code signals, electric field signals, magnet field signals, optical signals, electromagnetic signals and/or signals of other possible types.

OPERATION ALTERNATIVE 2:

In the transmitting situation, the feedback signal U_{LOAD} i.e., U_{l-n} is taken directly from the rail impedance Z_{LOAD} connecting points l-n or near the connecting points, usually from the

phase and zero rails. The feedback signal is brought to coupling unit/feedback 80 by separate conductors and further to ALC/AGC/ACC unit 90, where control voltage U_{ALC} , U_{AGC} and/or U_{ACC} to be produced, is taken to control the output or voltage signal of blocks 20, 40, 10 and/or 50 to such state that the load signal voltage U_{LOAD} , as rail signal voltage is constant or almost constant.